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METHOD FOR OPERATING A TRACK FOR A RAIL-BORNE VEHICLE, AND CORRESPONDING TRACK

The present invention relates to a method for the operation of a track for a rail-borne vehicle, especially a magnetic levitation track, whereby the vehicle is largely surrounded by a tunnel tube. In addition the invention relates to a corresponding track for a rail-borne vehicle in a tunnel, whereby the vehicle is largely surrounded by a tunnel tube and the vehicle is guided in the tunnel tube.

DE 40 21 834 A1 discloses a track configuration for a magnetic levitation track which extends essentially in a tunnel. The vehicle of the magnetic levitation track is guided on a track plate that is attached in the tunnel tube. The tunnel tube surrounds the vehicle at a relatively wide distance so that catwalks can be installed laterally next to the vehicle on the tunnel tube wall, on which travelers can reach emergency exits if required. Pressure compensation openings connecting the tube to the outside world are proposed for pressure compensation. The pressure compensation openings cause an outflow from the tube of the air displaced by the vehicle. In the examples shown they are in particularly shown with partially covered tracks, e.g. on a mountain slope.

DE 41 15 935 C2 also discloses a track extending in a tunnel tube. Here there is also a wide clearance between the vehicle and the tunnel wall, as required for the displacement of air as the vehicle goes through.

It is a disadvantage in the state of the art that the relatively large tunnel tubes are used as compared to the vehicles. These large tunnel tubes are very costly and time-consuming to produce. In addition, the encounter of rapidly traveling vehicle poses a problem in a tunnel with two rails, since the columns of air being pushed ahead cause problems that are still unsolved. The

vehicles must therefore pass each other at a relatively low speed. The alternatively necessary huge tunnel cross-sections are difficult to realize from an economic standpoint.

It is therefore the object of the present invention to create an economical method for the operation of a track of a rail-borne vehicle traveling in a high-speed range, especially in case of magnetic levitation tracks, and a corresponding track.

The object is attained by a method and a track having the characteristics of the independent claims.

According to the invention, the vehicle is closely surrounded by the tunnel tube with a method for the operation of a track of a rail-borne vehicle in a tunnel. The air displaced by the vehicle as it passes is directed through openings in the vehicle and/or through at least one air channel located outside or inside the tube and connected to the tube. The tunnel tube is made as narrow as possible, so that the production of the tunnel tube is economically feasible. Costs are reduced thereby and thus the operation of the vehicle becomes more economical.

The air displaced by the vehicle is either removed by means of a special design of the vehicle with passage openings, or is directed into air channels connected to the tube. These air channels can also be made with a very small cross-section. The production overall is thereby less expensive than in producing one single tunnel tub e with a large cross-section. In addition, sizing can be much more targeted and thereby an overall smaller cross-section can be realized.

The air channel serves advantageously as an escape and safety path. The air channel can be entered by persons through the connection between tunnel tube and air channel, and can be

reached by the travelers. Emergency personnel can reach the vehicle having had an accident and can carry out the necessary life-saving operations.

To ensure the required pressure compensation and availability of emergency exits, the tube and the air channel are connected over a plurality of openings. The openings may be of different sizes and can be closed if required.

If the tube is evacuated at least in part, the volume of compressed air is correspondingly reduced so that the air channel can also be of smaller size or may even be omitted.

It is especially advantageous if the displaced air is directed passively by the movement of the vehicle into the air channel. The dynamic pressure produced as the vehicle travels through the tube then pushes the displaced air through the openings into the air channel in which it is removed or returned into the tube behind the vehicle. In addition or alternatively, the displaced air can be directed actively, in particular by a turbine, through the vehicle or into the air channel. The turbine produces an air flow which counteracts the build-up of the dynamic pressure. As a result the vehicle can be operated most advantageously in an energy-saving manner since it does not have to displace the complete air column as in passive operation.

On a track according to the invention of a rail-borne vehicle, in particular a magnetic levitation track in a tunnel, the vehicle is largely surrounded by a tunnel tube. Built-on parts are provided in the tunnel tube to guide the vehicle. The tunnel tube encloses the vehicle closely. The air displaced by the vehicle as it goes through the tunnel is directed through openings of the vehicle and/or through air channels located outside or inside the tube and connected to the tube.

The track according to the invention is economical to produce since a minimally required tunnel tube is used. The production of such a tunnel tube with a small cross-section is considerably more economic than the production of a large tunnel tube. A narrow tube with a cross-section that is barely larger than the cross-section of the vehicle, in addition to considerably lower building costs also offers advantages for the operation of the vehicle. The guidance of the vehicle can e.g. be integrated directly into the tunnel tube, so that special supports in addition to the tunnel tube are hardly or not at all required. The air channels connected to the tube can also be produced with a very small cross-section that is distinctly smaller than the cross-section of the actual tunnel tube.

In an inventive and advantageous manner add-on pieces for the guidance of the vehicle are provided on the wall of the tunnel tube. Due to the fact that the gap between the vehicle and the tunnel tube is narrow, the built-on parts can be integrated directly into the tunnel wall. This allows for especially economic production of the complete system consisting of tube and vehicle guidance.

If the add-on pieces are stator surfaces, lateral guide rails, gliding laths and/or stabilizers, the electrical and mechanical guidance of the vehicle by elements built into the wall is ensured in a very simple manner. The guidance of the vehicle can then be carried out through add-on pieces lying flat against the tunnel tube and/or protruding at an angle and/or protruding as flat surfaces.

The different add-on pieces advantageously unite several guidance and drive functions within themselves. Thus stator surfaces installed at an angle can for example also play a lateral guiding role. Separate lateral guide rails can thus be omitted entirely or in part.

If the air channel is provided with installations to be used as an escape and rescue path, an aspect in the area of safety technology must also be resolved in addition to the functionality of receiving

air as the vehicle passes. Vehicles involved in an accident and its passengers can escape or be rescued through the air channel. The necessary installations may be e.g. even walkways or roads, fire extinguishers, alarm devices, telephones, ladders, stairs, elevators or stairways going to the surface or illuminations that are helpful for escape or rescue.

If the air channel is connected to the ground surface, pressure compensation can be effected directly with the environmental outside air.

If the tube and the air channel are connected to a plurality of openings, the transfer from tunnel tube into the air channel is possible for passengers and rescue personnel at many locations. Evacuation or rescue can thus be rapid and reliable. In addition, the air displaced by the vehicle is certain to be able to escape rapidly from the tunnel tube into the air channel so that the travel resistance of the vehicle is reduced. For this it is also an especial advantage if the openings are of a size that ensures that the air displaced by the vehicle is able to escape completely into the air channel. This applies of course also to the size of the air channel which must also be sized so that the displaced air can be received by the air channel at least for the greatest part.

It is especially advantageous if the edges of the opening are designed so as to favor flow. The displaced air can then flow into the air channel and back into the tunnel tube without major flow resistance.

The openings between tube and air channel can advantageously be closed. Thus it can be ensured in case of a fire that the escape route is preserved. Furthermore, the air guidance can be influenced in a targeted manner with vehicles meeting each other in the tunnel tube.

If the tube is provided with devices for the at least partial evacuation of the tube, only a small amount of air is to be displaced. The air channels can accordingly be small, and this in turn makes a very economic production of the air channels possible.

If the cross-sectional forms of the tube and of the vehicle are substantially identical the cross-section of the tube is mostly filled out by the vehicle. Only a small amount of air flows past the vehicle inside the tube. The displaced air in front of the vehicle is removed in this case almost completely into the air channel or channels. In order to further reduce the dynamic pressure to which the vehicle is subjected as it travels through the tunnel it is advantageous to equip the turbine and/or the vehicle with a turbine. The air to be displaced is pre-accelerated by the turbine so that it need not be put in motion by the vehicle alone. The flowing-off into the air channel or through the vehicle can be accelerated thereby. The travel resistance of the vehicle is thus considerably reduced.

It is especially advantageous if the turbine is installed in the area of a recess in the vehicle relative to the tunnel and/or the air channel. While the tunnel tube essentially surrounds the vehicle closely, the vehicle can be recessed in the area where a turbine is installed in the tube so that as it travels over the turbine it does not collide with it. Alternatively it is also possible to be fixedly installed in the vehicle and accordingly accelerate the air. The turbine can serve as propulsion by reaction of the vehicle in that case and thus assist in the actual propulsion of the vehicle.

In another possible embodiment the turbine is located in the air channel and already accelerates the air therein and if necessary guides it by means of a suitable air guidance system out of the tunnel tube into the air channel as soon as the vehicle approaches that particular location in the tunnel. Usually it suffices if the turbine is started up just before the vehicle passes. Continuous operation is usually not required.

If the turbine is located at the tunnel entrance and or at points of encounter in the tunnel, the areas in which compressed air acts with particular force upon the vehicle can be disarmed. The thrust of compressed air at the tunnel entrance as well as where a vehicle coming in the opposite direction in the tunnel is encountered is reduced significantly by a suitably actuated turbine, since the compressed air is conveyed very rapidly by that turbine, in particular into the air channel.

Additional advantages of the invention are described in the following examples of embodiments.

Figs. 1 – 3 show different cross-sections of tunnel tubes and vehicles,

Figs. 4 – 6 show different tunnel cross-sections with vehicles with active air displacement,

Fig. 7 shows a vehicle in a tunnel tube with air channels and

Fig. 8 shows two vehicles crossing each other in tunnel tubes with a common air channel.

Fig. 1 shows a tunnel tube 1 in cross-section which closely surrounds a vehicle 2. The vehicle 2 is essentially of circular construction just like the tunnel tube 1. To guide and advance the vehicle 2, add-on pieces 3 are installed in the tunnel tube. Via these add-on pieces 3 the vehicle is able to move in longitudinal direction relative to the tunnel tube 1 by means of suitable propulsion means not shown here, e.g. a magnet drive. The distribution of the add-on pieces 3 on the circumference of the tunnel tube 1 exerts a certain stabilization on the vehicle 2 so that a quiet running of the vehicle 2 is made possible. The add-on pieces 3 are integrated into the tunnel wall and assume the combined functions of the lateral guide rails, the gliding laths and the stator surfaces of conventional systems.

The ram air produced by the vehicle 2 as it travels through the tunnel tube 1 is pushed ahead in front of the vehicle 2. As shall be described further below, the removal of this air through different systems is made possible by the invention.

Fig. 2 shows another embodiment of a tunnel tube 1 and of a vehicle 2. The add-on pieces 3 of the tunnel tube 1 extend into the tunnel cross-section and thereby further stabilize the vehicle 2. The add-on pieces 3 and the corresponding drive elements of the vehicle 2 are additionally guided by the configuration of the add-on pieces 3 and their angle of installation on the tunnel wall and cause the running of the vehicle 2 to be especially quiet. The upper add-on pieces 3 assume the functions of the stator surfaces and lateral guide rails, while the lower add-on pieces 3 assume the functions of gliding laths and of the lateral guide rails.

According to the embodiment of Fig. 3 the tunnel tube 1 has add-on pieces 3 that extend on the one hand at an angle into the cross-section of the tunnel tube 1 as shown in the design of Fig. 2. In addition an additional add-on element 3' in the manner of a routing circuit is provided and also extends into the interior of the tunnel tube 1. The vehicle 2 supports itself with its stator surfaces and lateral guide rails against the add-on pieces 3 and 3' and thus make a stable running of the vehicle possible. The add-on pieces 3 and 3' assume in turn combined tasks of the drive and the guidance of the vehicle 2.

Fig. 4 shows a sketch of a tunnel tube 1 and of a vehiccle2 according to the principle of Fig. 1. The add-on pieces 3 are located at the circumference of the tunnel tube 1. A turbine 4 which aspires the air to be displaced through an air inlet 5 guides it through the vehicle 2 and expels it again at the end of the vehicle 2 is provided in the vehicle 2. The dynamic pressure is thus considerably lower than with a vehicle 2 traveling through the narrow tube without such an assist. The turbine 4 furthermore causes the vehicle 2 to be further accelerated by the recoil as the air is

expelled at the end of the vehicle 2. The vehicle 2 can thus be operated in an energy-saving manner.

In Fig. 5 a support 6 is provided in the tunnel tube 1. On the supports 6 are add-on pieces 3 ensuring the drive and lateral guidance of the vehicle 2 together with the drive means of the vehicle 2. An empty space exists between the supports 6 and is not filled by the vehicle 2. This empty space constitutes the air channel 8 through which the displaced air of the vehicle 2 is guided past the vehicle 2. In this empty space, and at certain distances from each other or at each of certain critical points such as e.g. at the tunnel entrance or at meeting points, is a turbine 4. The turbine 4 is fixedly attached at that location and ensures pressure compensation as the vehicle 2 approaches and goes over the turbine 4. At lower travel speeds or with a suitable size of the tube 1 it is also possible to omit the turbine 4.

The add-on pieces 3 as well as the drive system of the vehicle 2 are essentially those of the state of the art for the driving of magnetic levitation vehicles. For such an application of the invention, merely the required configuration of the vehicle 2 would be necessary.

Fig. 6 shows a tunnel tube 1 with supports 6 and add-on pieces 3 as in Fig. 5. By contrast to the embodiment according to Fig. 5, two turbines 4 are installed on the vehicle 2 in the embodiment of Fig. 6. The turbines 4 are in operation especially during travel in the tunnel 1 and actively convey the ram air through the vehicle 2 towards its end. The turbines 4 are located at the top and on the underside of the vehicle 2 so that the central area is available for passengers or transported goods.

Fig. 7 shows a sketched representation of a tube system in cross-section and top view. The tunnel tube 1 through which the vehicle 2 travels is located in the center between two air channels 8.

One single air channel 8 may also suffice. The tunnel tube 1 is connected to the air channels 8 via openings 9. As the vehicle 2 travels through the tube 1, the air displaced by the vehicle is pressed through the openings 9 into the air channels 8. The displaced air masses flow back into the tunnel tube 1 behind the vehicle 2 and ensure pressure compensation at that point.

A system of this type is especially easy to realize as the required tubes 1 and 8 can easily be driven into a mountain. The tubes 8 are used additionally as escape and rescue paths through which a damaged vehicle 2 can be supplied. The openings 9 and the air channels 8 are sized so that the air displaced by the vehicle 2 is received to a great extent. The resistance against vehicle 2 as it travels through the narrow tunnel tube 1 is thereby minimized. The edges of the openings are advantageously designed so as to favor flow in order to allow the displaced air to flow without great flow resistance into the air channel and back into the tunnel tube.

The air channel 8 is used in addition as escape and rescue path for both tunnel tubes 1. For this reason it is provided with a catwalk or travel path 10 located on the bottom of the air channel 8.

The present invention is not limited to the examples of embodiments shown. In particular combinations of the different embodiments as well as embodiments not shown falling within the protection scope of the claims are possible. The air channel need not be always parallel to the tunnel tube. It may also be directed towards the earth surface in order to make pressure compensation possible at that point.